# Appendix K
# Other Hazards

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## K.1 Other Hazards Considered by HMPSC

The Hazard Mitigation Plan Stakeholder Committee considered a wide range of hazards with the potential to impact the City of Galveston. The list of hazards was compiled from the following sources:

- The Galveston County Plan Update
- The State of Texas's Hazard Mitigation Plan
- FEMA 386, the *How-To* Series
- Local history and knowledge

The following table illustrates the complete list of hazards that were considered by the HMPSC for inclusion in the Plan.

**Table K.1-1**
**Hazards Considered by Galveston HMPSC**

| Hazards Considered for Inclusion in Plan | | | | |
|---|---|---|---|---|
| **Hazard** | **Profiled in Galveston County Update (2010)?** | **Risk /Vulnerability Assessment in 2010 Update?** | **Included in State Mitigation Plan (2008)?** | **Profiled in City Plan?** |
| Coastal Erosion | No | No | Yes | Yes |
| Coastal Retreat | No | No | Yes | Yes |
| Coastal Subsidence | No | No | Yes | Yes |
| Dam / Levee Failure | Yes | Yes | Yes (as Dam and Levee Failure) | No |
| Drought | Yes | Yes | Yes | Yes |
| Flooding – Coastal and Inland | Yes | Yes | Yes (as Flooding) | Yes |
| Earthquake | Yes | Yes | Yes | No |
| Expansive Soils | No | No | Yes | No |
| Extreme Heat | Yes | Yes | Yes | No |

| Hazards Considered for Inclusion in Plan | | | | |
|---|---|---|---|---|
| **Hazard** | **Profiled in Galveston County Update (2010)?** | **Risk /Vulnerability Assessment in 2010 Update?** | **Included in State Mitigation Plan (2008)?** | **Profiled in City Plan?** |
| Hail | Yes | Yes | Yes (as Hailstorm) | No |
| HazMat Incident | Yes | Yes | No | Yes |
| Hurricane Wind (includes surge) | Yes | Yes | Yes (as Tropical Storms and Hurricanes | Yes – as Extreme Wind |
| Land Subsidence | No | No | Yes | Yes – as Coastal Subsidence |
| Pipeline Failure | Yes | Yes | No | Yes – as HazMat |
| Tornado | Yes | Yes | Yes | Yes – as Extreme Wind |
| Tsunami | Yes | Yes | No | Yes |
| Urban Fire/Wildfire | Yes | Yes | Yes (as Wildfire) | Yes |
| Windstorm | No | No | Yes (excludes tornadoes and tropical systems) | Yes – as Extreme Wind |
| Winter Storm | Yes | Yes | Yes (as Severe Winter Storm) | No |
| **Additional Hazards Not Included in Other Planning Efforts:** | | | | |
| Sea Level Rise | | | | Yes |
| Biologic Hazard | | | | Yes |
| Terrorism (see matrix) | | | | Yes |
| Lightning | | | | Yes |
| Communicable Disease/Pandemic | | | | Yes – as Biologic Event |
| Aircraft Incident | | | | No |
| Landslide | | | | No |
| Volcano | | | | No |
| Extreme Wind Events | | | | Yes |

# K.2 Descriptions of Hazards Not Selected for Profiling

This section contains information on those hazards that the HMPSC determined were not to be included in Section 6 (Hazard Identification, Profiling and Ranking) of this Plan. This section includes a discussion of why the hazard was not selected.

## K.2.1 Aircraft Incident

An aircraft incident can be described as any occurrence with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and the time

when all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. Some of the more well known and recent aircraft incidents have been caused by aircraft malfunction, bird interference and terrorist takeover.

Discussion among the Stakeholder Committee members concluded that the aircraft incident hazard, while possible, was not a substantial enough threat to the City of Galveston, and elected not to profile this hazard in the Plan.

## K.2.2 Dam and Levee Failure

A dam or levee failure is defined as a systematic failure of the dam or levee structure resulting in the uncontrolled release of water, often resulting in floods that could exceed the 100-year flood plain boundaries.

There are no traditional dams or levees in the City of Galveston. Failure of the Seawall would not result in an uncontrolled release of water, as the Seawall's design and placement is to prevent surge inundation rather than to contain water. This hazard was not selected due to its lack of potential to impact the City of Galveston.

## K.2.3 Earthquake

An earthquake is a sudden motion or trembling of the earth caused by an abrupt release of stored energy in the rocks beneath the earth's surface. The energy released results in vibrations known as seismic waves that are responsible for the trembling and shaking of the ground during an earthquake. Ground motion is expressed as peak ground acceleration (PGA).

Earthquake severity is measured on the Richter Scale which assigns a single number to quantify the amount of seismic energy released by an earthquake. The following table describes the severity of an earthquake based on the Richter/Mercalli scales.

**Table K.2.3-1**
**Earthquake: Richter/Mercalli Scale**

| Peak Ground Acceleration/Mercalli/Richter Scale Comparison | | | |
|---|---|---|---|
| **Mercalli Scale** | **PGA** | **Richter Scale** | **Full Description** |
| **I.** | **<0.17** | **0 – 1.9** | Not felt. Marginal and long period effects of large earthquakes. |
| **II.** | **0.17 – 1.4** | **2.0 -2.9** | Felt by persons at rest, on upper floors, or favorably placed. |
| **III.** | | **3.0 – 3.9** | Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake. |
| **IV.** | **1.4-3.9** | **4.0 - 4.3** | Hanging objects swing. Vibration like passing of heavy trucks. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink the upper range of IV, wooden walls and frame creak. |
| **V.** | **3.9-9.2** | **4.4 - 4.8** | Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Pendulum clocks stop, start. |
| **VI.** | **9.2-18** | **4.9 - 5.4** | Felt by all. Many frightened and run outdoors. Persons walk |

| Peak Ground Acceleration/Mercalli/Richter Scale Comparison | | | |
|---|---|---|---|
| **Mercalli Scale** | **PGA** | **Richter Scale** | **Full Description** |
| | | | unsteadily. Windows, dishes, glassware broken. Books, etc., off shelves. Pictures off walls. Furniture moved. Weak plaster and masonry D cracked. Small bells ring. Trees, bushes shaken. |
| **VII.** | **18-34** | **5.5 - 6.1** | Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices. Some cracks in masonry C. Waves on ponds. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged. |
| **VIII.** | **34-65** | **6.2 - 6.5** | Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. |
| **IX.** | **65-124** | **6.6 - 6.9** | General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters. |
| **X.** | **>124** | **7.0 - 7.3** | Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly. |
| **XI.** | | **.7.4 - 8.1** | Rails bent greatly. Underground pipelines completely out of service. |
| **XII.** | | **> 8.1** | Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air. |
| Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; | | | |
| Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces. | | | |
| Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces. | | | |
| Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally. | | | |
| Source: http://www.abag.ca.gov/bayarea/eqmaps/doc/mmigif/m10.html | | | |

While this hazard has the potential to impact Galveston, it was not selected for profiling due to its low probability of occurrence and lack of any local knowledge regarding previous occurrences.

## K.2.4 Expansive Soils

Expansive soils in many parts of the United States pose a significant hazard to foundations for light buildings. Swelling clays derived from residual soils can exert uplift pressures of as much as 5,500 PSF, which can do considerable damage to lightly-loaded wood-frame structures. Insurance companies pay out millions of dollars yearly to repair homes distressed by expansive soils.

Expansive soils owe their characteristics to the presence of swelling clay minerals. As they get

wet, the clay minerals absorb water molecules and expand; conversely, as they dry they shrink, leaving large voids in the soil. Swelling clays can control the behavior of virtually any type of soil if the percentage of clay is more than about 5 percent by weight. Soils with smectite clay minerals, such as montmorillonite, exhibit the most profound swelling properties.

**Table K.2.4-1**
**Expansive Soils: Percent of Change**

| Expansion Index (in %) | |
|---|---|
| 0–20 | Very Low |
| 21-50 | Low |
| 51-90 | Medium |
| 91-130 | High |
| >130 | Very High |

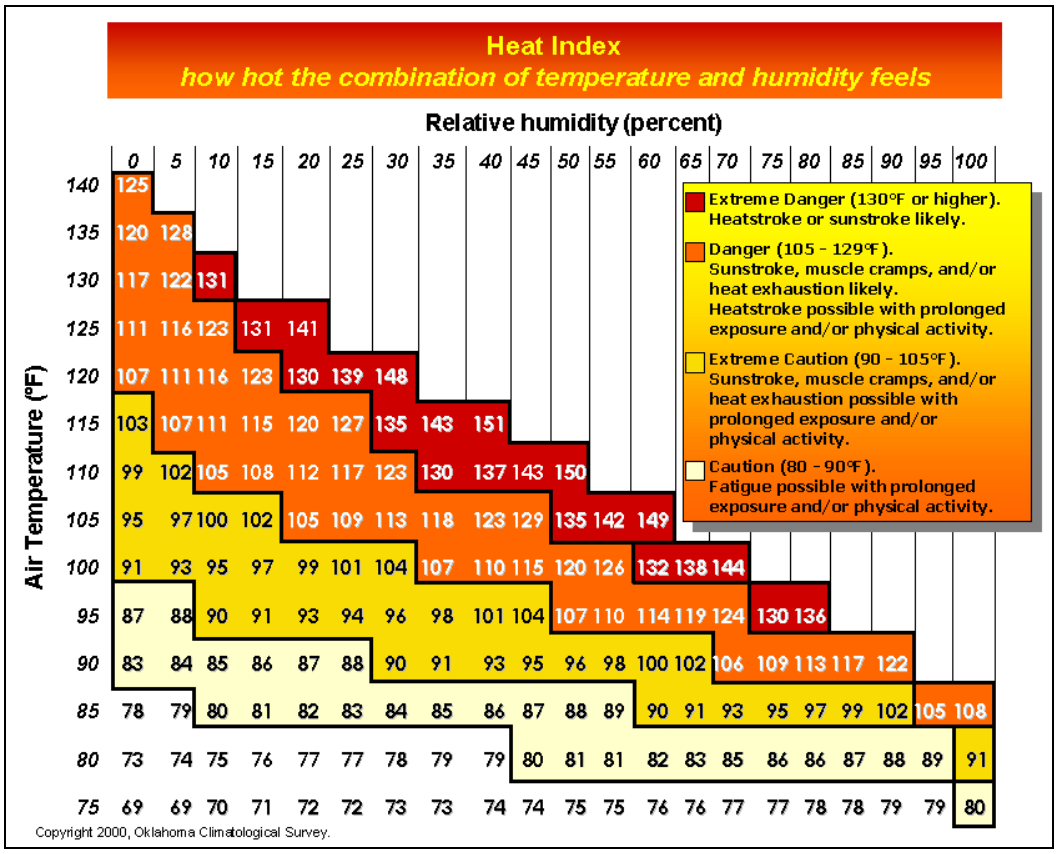
This hazard was not selected by the Stakeholder Committee due to its low probability of occurrence, based on the geologic structure of Galveston Island.

## K.2.5 Extreme Heat

Heat kills by pushing the human body beyond its limits. In extreme heat and high humidity, evaporation is slowed and the body must work extra hard to maintain a normal temperature. Most heat disorders occur because the victim has been overexposed to heat or has over-exercised for his or her age and physical condition. Older adults, young children, and those who are sick or overweight are more likely to succumb to extreme heat.

Conditions that can induce heat-related illnesses include stagnant atmospheric conditions and poor air quality. Consequently, people living in urban areas may be at greater risk from the effects of a prolonged heat wave than those living in rural areas. Also, asphalt and concrete store heat longer and gradually release heat at night, which can produce higher nighttime temperatures known as the "urban heat island effect."

**Table K.2.5-1**
**Heat Index**




This hazard was not selected for inclusion by the Stakeholder Committee due to the member's personal experiences with extreme heat. Members noted that while this hazard may occur in other parts of the country, "extreme" heat in Texas is an annual occurrence.

## K.2.6 Hailstorm

Hail is defined as falling ice, roughly round in shape and at least 0.2' in diameter. Hail develops in the upper atmosphere as ice crystals that are bounced about by high velocity updraft winds; the ice crystals accumulate frozen droplets and fall after developing enough weight. The size of hailstones varies and is a direct consequence of the severity and size of the storm that produces them – the higher the temperatures at the Earth's surface, the greater the strength of the updrafts and the amount of time hailstones are suspended, the greater the size of the hailstone.

**Table K.2.6-1**
**NOAA/TORRO Hail Scale**

| Combined NOAA/TORRO Hailstorm Intensity Scales | | | | |
|---|---|---|---|---|
| **Size Code** | **Intensity Category** | **Typical Hail Diameter (inches)** | **Approximate Size** | **Typical Damage Impacts** |
| H0 | Hard Hail | up to 0.33 | Pea | No damage |
| H1 | Potentially Damaging | 0.33-0.60 | Marble or Mothball | Slight damage to plants, crops |
| H2 | Potentially Damaging | 0.60-0.80 | Dime or grape | Significant damage to fruit, crops, vegetation |
| H3 | Severe | 0.80-1.20 | Nickel to Quarter | Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored |
| H4 | Severe | 1.2-1.6 | Half Dollar to Ping Pong Ball | Widespread glass damage, vehicle bodywork damage |
| H5 | Destructive | 1.6-2.0 | Silver dollar to Golf Ball | Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries |
| H6 | Destructive | 2.0-2.4 | Lime or Egg | Aircraft bodywork dented, brick walls pitted |
| H7 | Very destructive | 2.4-3.0 | Tennis ball | Severe roof damage, risk of serious injuries |
| H8 | Very destructive | 3.0-3.5 | Baseball to Orange | Severe damage to aircraft bodywork |
| H9 | Super Hailstorms | 3.5-4.0 | Grapefruit | Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open |
| H10 | Super Hailstorms | 4+ | Softball and up | Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open |

This hazard was not selected by the Committee due to the infrequency with which it occurs in Galveston, and the lack of known damage on the occasions when it has occurred.

## K.2.7 Hurricane

Hurricanes were not treated as a separate hazard in this Plan. Rather, the individual hazards associated with hurricanes – namely extreme wind and flooding – were included in Section 6 (Hazard Profiles).

## K.2.8 Land Subsidence

This hazard was addressed in the Coastal Subsidence profile, found in Section 6.

## K.2.9 Landslide

Landslides occur in all U.S. states and territories. In a landslide, masses of rock, earth, or debris move down a slope. Landslides may be small or large, slow or rapid. They are activated by storms, earthquakes, volcanic eruptions, fires, alternate freezing or thawing, and steepening of slopes by erosion or human modification.

Debris and mud flows are rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry." They can flow rapidly, striking with little or no warning at avalanche speeds. They also can travel several miles from their source, growing in size as they pick up trees, boulders, cars, and other materials.

Landslide problems can be caused by land mismanagement, particularly in mountain, canyon, and coastal regions. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Land-use zoning, professional inspections, and proper design can minimize many landslide, mudflow, and debris flow problems.

**Table K.2.9-1**
**Alexander Scale for Landslide Damage**

| Alexander Scale for Landslide Damage | | |
|---|---|---|
| **Level** | **Damage** | **Description** |
| **0** | None. | Building is intact |
| **1** | Negligible. | Hairline cracks in walls or structural members; no distortion of structure or detachment of external architectural details |
| **2** | Light. | Buildings continue to be habitable; repair not urgent. Settlement of foundations, distortion of structure, and inclination of walls are not sufficient to compromise overall stability. |
| **3** | Moderate. | Walls out of perpendicular by one or two degrees, or there has been substantial cracking in structural members, or the foundations have settled during differential subsidence of at least 15 cm; building requires evacuation and rapid attention to ensure its continued life. |

| Alexander Scale for Landslide Damage | | |
|---|---|---|
| **Level** | **Damage** | **Description** |
| **4** | Serious. | Walls out of perpendicular by several degrees; open cracks in walls; fracture of structural members; fragmentation of masonry; differential settlement of at least 25 cm compromising foundations; floors may be inclined by one or two degrees or ruined by heave. Internal partition walls will need to be replaced; door and window frames are too distorted to use; occupants must be evacuated and major repairs carried out. |
| **5** | Very Serious. | Walls out of plumb by five or six degrees; structure grossly distorted; differential settlement has seriously cracked floors and walls or caused major rotation or slewing of the building [wooden buildings are detached completely from their foundations]. Partition walls and brick infill will have at least partly collapsed; roofs may have partially collapsed; outhouses, porches, and patios may have been damaged more seriously than the principal structure itself. Occupants will need to be re-housed on a long-term basis, and rehabilitation of the building will probably not be feasible. |
| **6** | Partial Collapse. | Requires immediate evacuation of the occupants and cordoning of the site to prevent accidents with falling masonry. |
| **7** | Total Collapse. | Requires clearance of the site. |

Landslides were not chosen for profiling by the Stakeholder Committee due to the fact that they are highly unlikely to occur in an area with elevation as low as Galveston.

## K.2.10 Mosquito-Borne Disease/Communicable Disease/Pandemic

These hazards are addressed in 6.3.1, Biologic Events.

## K.2.11 Winter Storm

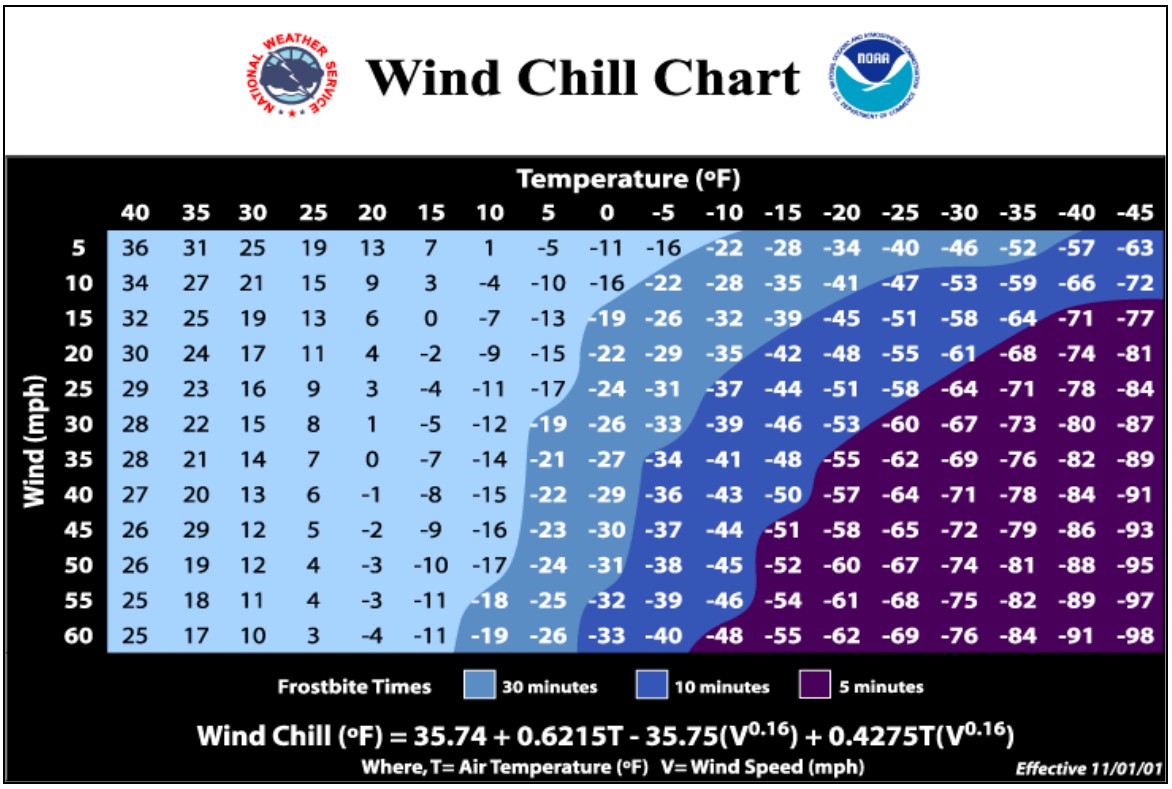
Winter storms consist of freezing temperatures and heavy precipitation, usually in the form of rain, freezing rain, sleet or snow. Winter storms include all forms of significant frozen precipitation.

The *Wind Chill* temperature commonly referenced is simply a measure of how cold the wind makes real air temperature feel to the human body. Since wind can dramatically accelerate heat loss from the body, a blustery 30° day would feel just as cold as a calm day with 0° temperatures. The index was created in 1870, and on November 1, 2001, the National Weather Service released a more scientifically accurate equation, which is currently in use. (Please note that it is not applicable in calm winds or when the temperature is over 50°.)

The following National Weather Service chart describes the methodology for determining wind chill.

**Table K.2.11-1**

**Wind Chill Chart**




| Wind (mph) | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 | -10 | -15 | -20 | -25 | -30 | -35 | -40 | -45 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 36 | 31 | 25 | 19 | 13 | 7 | 1 | -5 | -11 | -16 | -22 | -28 | -34 | -40 | -46 | -52 | -57 | -63 |
| 10 | 34 | 27 | 21 | 15 | 9 | 3 | -4 | -10 | -16 | -22 | -28 | -35 | -41 | -47 | -53 | -59 | -66 | -72 |
| 15 | 32 | 25 | 19 | 13 | 6 | 0 | -7 | -13 | -19 | -26 | -32 | -39 | -45 | -51 | -58 | -64 | -71 | -77 |
| 20 | 30 | 24 | 17 | 11 | 4 | -2 | -9 | -15 | -22 | -29 | -35 | -42 | -48 | -55 | -61 | -68 | -74 | -81 |
| 25 | 29 | 23 | 16 | 9 | 3 | -4 | -11 | -17 | -24 | -31 | -37 | -44 | -51 | -58 | -64 | -71 | -78 | -84 |
| 30 | 28 | 22 | 15 | 8 | 1 | -5 | -12 | -19 | -26 | -33 | -39 | -46 | -53 | -60 | -67 | -73 | -80 | -87 |
| 35 | 28 | 21 | 14 | 7 | 0 | -7 | -14 | -21 | -27 | -34 | -41 | -48 | -55 | -62 | -69 | -76 | -82 | -89 |
| 40 | 27 | 20 | 13 | 6 | -1 | -8 | -15 | -22 | -29 | -36 | -43 | -50 | -57 | -64 | -71 | -78 | -84 | -91 |
| 45 | 26 | 29 | 12 | 5 | -2 | -9 | -16 | -23 | -30 | -37 | -44 | -51 | -58 | -65 | -72 | -79 | -86 | -93 |
| 50 | 26 | 19 | 12 | 4 | -3 | -10 | -17 | -24 | -31 | -38 | -45 | -52 | -60 | -67 | -74 | -81 | -88 | -95 |
| 55 | 25 | 18 | 11 | 4 | -3 | -11 | -18 | -25 | -32 | -39 | -46 | -54 | -61 | -68 | -75 | -82 | -89 | -97 |
| 60 | 25 | 17 | 10 | 3 | -4 | -11 | -19 | -26 | -33 | -40 | -48 | -55 | -62 | -69 | -76 | -84 | -91 | -98 |

Winter Storms were not selected by the Stakeholder Committee due to the rarity of their occurrence and the minimal disruption or damage that they cause when they do occur.

## K.2.12 Thunderstorm (Windstorm)

Thunderstorms were not profiled as a separate hazard in this Plan. Rather, their hazards – extreme wind and lightning – were profiled in Section 6 (Hazard Profiles).

## K.2.13 Tornado

Tornadoes were not profiled as a separate hazard in this Plan. Rather, their primary hazard – extreme wind – was profiled in Section 6 (Hazard Profiles).

## K.2.14 Volcano

A volcano is a mountain that opens downward to a reservoir of molten rock below the surface of the earth. Unlike most mountains, which are pushed up from below, volcanoes are built up by an accumulation of their own eruptive products. When pressure from gases within the molten rock becomes too great, an eruption occurs. Eruptions can be quiet or explosive. There may be lava flows, flattened landscapes, poisonous gases, and flying rock and ash.

Because of their intense heat, lava flows are great fire hazards. Lava flows destroy everything in their path, but most move slowly enough that people can move out of the way.

Fresh volcanic ash, made of pulverized rock, can be abrasive, acidic, gritty, gassy, and odorous. While not immediately dangerous to most adults, the acidic gas and ash can cause lung damage to small infants, to older adults, and to those suffering from severe respiratory illnesses. Volcanic ash also can damage machinery, including engines and electrical equipment. Ash accumulations mixed with water become heavy and can collapse roofs. Volcanic ash can affect people hundreds of miles away from the cone of a volcano.

Volcanic eruptions can be accompanied by other natural hazards, including earthquakes, mudflows and flash floods, rock falls and landslides, acid rain, fire, and (under special conditions) tsunamis.

Volcanoes were not selected by the Stakeholder Committee due to the distance to the nearest known volcano from Galveston – several thousand miles.